Raytheon

Communications and Networking

Simulation Based Network Protocol Design

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23-October-2003

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Agenda

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- Introduction
- Objectives
- Network Protocol Engineering Process
- Flexibility
- Conclusion
- Questions

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Raytheon Networked Communication Systems Fullerton, CA

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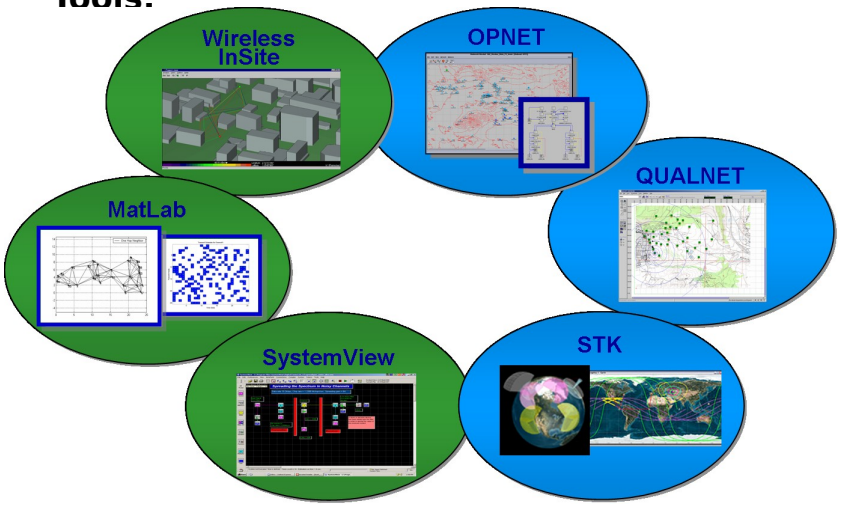
Team Overview:

- Talented team with diverse backgrounds in tactical networking, military communications, software/computer science, systems engineering, and mathematics.
- "Center of Excellence" for Modeling and Simulation in the tactical communications and networking arena.
- Simulation team members work directly with project engineers and domain experts – involved in all phases of the program.
- Continuous internal training program to ensure all engineers remain current on modeling techniques and new model sets.
- Over $1.5 M in hardware and software invested to support networking and M & S activities.
- Implement strict policies, procedures, and coding standards on every project to ensure quality products.

Current Programs:

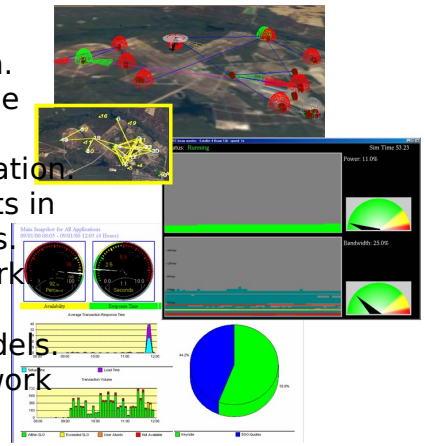
- DARPA Future Combat System-Communications (FCS-C)
- U.S. Army Tactical Internet (TI)/U.S. Army Aviation Integration
- FCS LSI (Boeing) Modeling and Simulation support
- Netfires
- Mobile User Objective System (MUOS) Concept Advanced Design Phase
- DD(X)
- Air Missile Defense (AMD)-IRAD
- Airborne C4ISR-IRAD
- Dynamic Bandwidth Resource Allocation (DBRA)
- Transformational Communications Architecture (TCA) Proposal and Enterprise Campaign
- Florako Link-16 Risk Reduction
- Common Aviation Command and Control System (CAC2S)
- Multi-sensor Command and Control Aircraft (MC2A) Proposal
- sLAMRAAM Proposal

Tools:



Strengths:

- Advanced networking protocol prototyping and development.
- Alternative architecture comparison.
- Communication system performance evaluation and analysis.
- 2-D and 3-D visualization and animation.
- Integration of communication effects in distributed simulation environments.
- Satellite communication and network architecture validation.
- Development of HLA compliant models.
- Integration of simulations with network management tools.
- RF waveform simulation and design support.



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Objectives

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- Accurately represent the effects of communications and networking protocols.
- Robust design to allow for the implementation of any communication protocol and networking architecture.
- Flexible design.
  - Adaptable to different simulator configurations.
  - Adaptable for use throughout all phases of the design process.

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Network Protocol System Engineering Process

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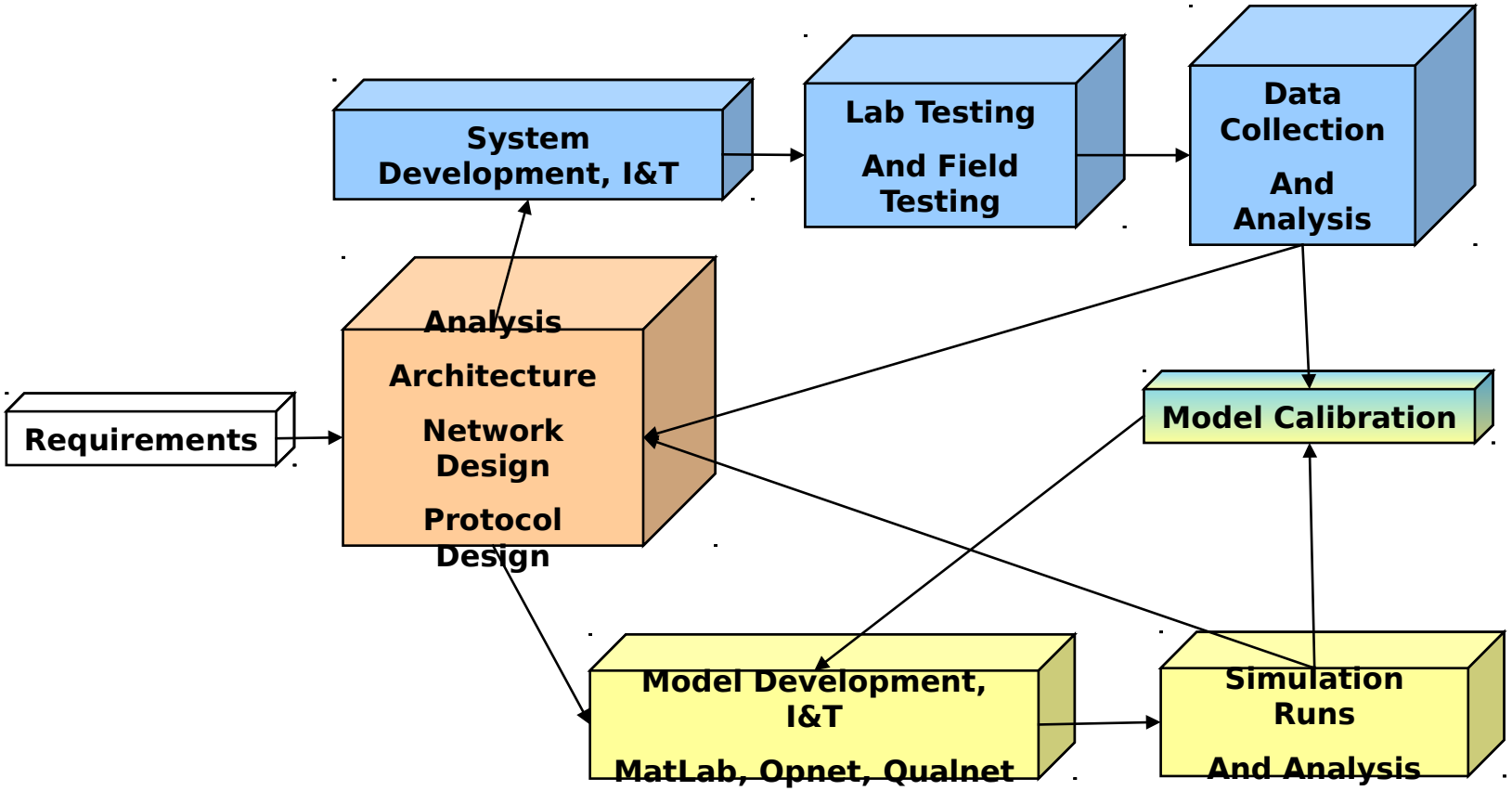

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Simulation as a Key Tool

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- **Simulation based protocol development**
  - **MatLab algorithm development**
  - **Opnet model protocol implementation**
    - » **Message completion rate and latency**
    - » **Scalability**
    - » **Motion**
    - » **Dynamic connectivity**
    - » **RF- Channel model**
  - **Simulation based trade studies**
    - » **Protocol development**
    - » **Parameter optimization**
    - » **Feedback results into architecture**
  - **Model calibration**
    - » **Calibrate model against system performance**
    - » **Verify / Predict system performance**

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MatLab to Quickly Prototype Algorithms

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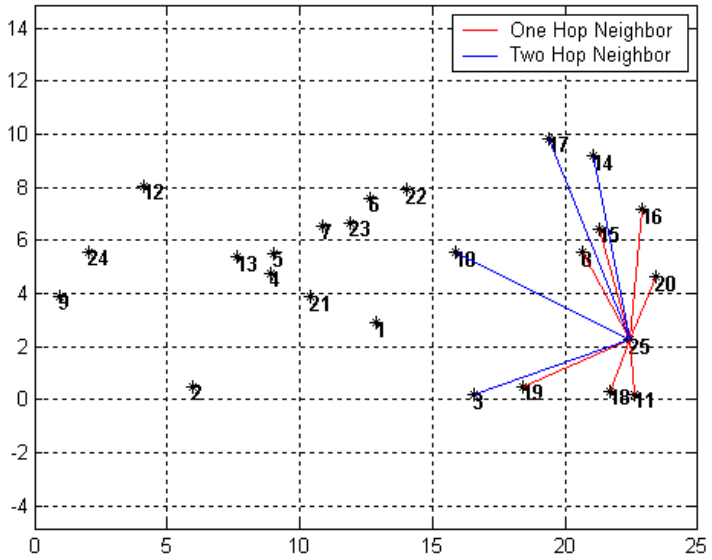
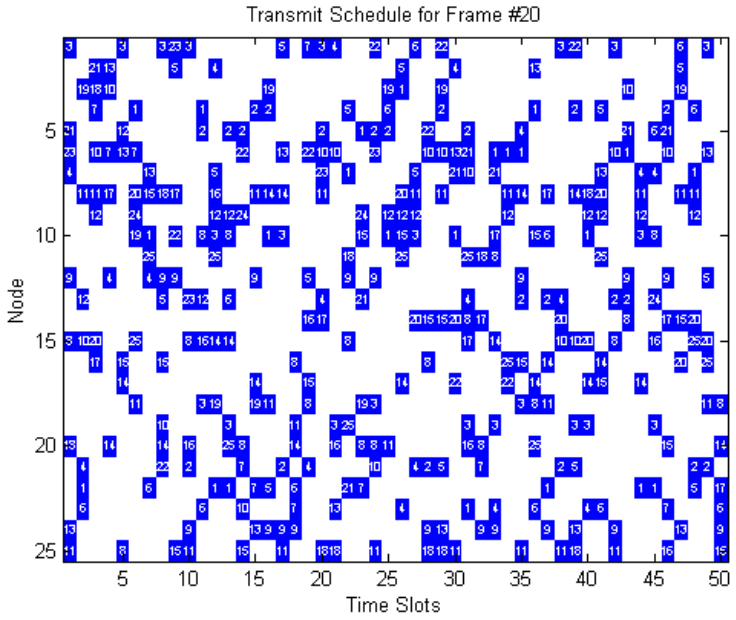
- **Dynamic TDMA Scheduler Example**
  - **Distributed algorithm**
  - **Goal is to design conflict free schedule**





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Opnet Node Model

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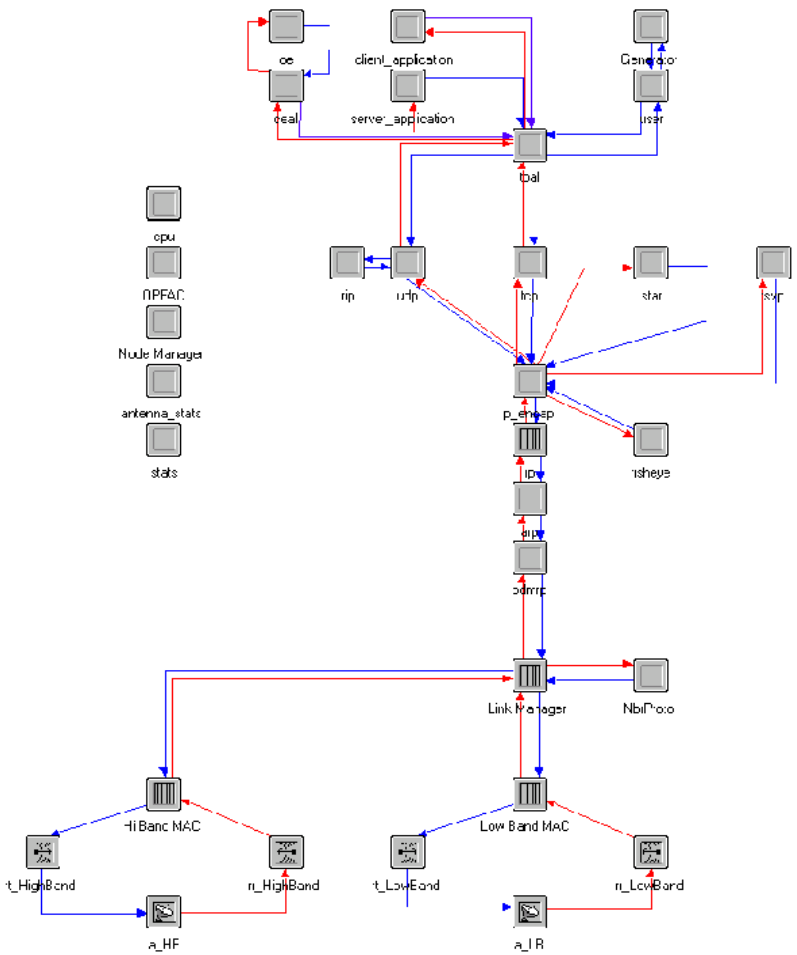

- Traffic
- TPAL
- UDP
- IP
- unicast routing
- multicast routing
- Link Manager
- Link/ MAC
- Neighbor
- PHY

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Simulation Analysis

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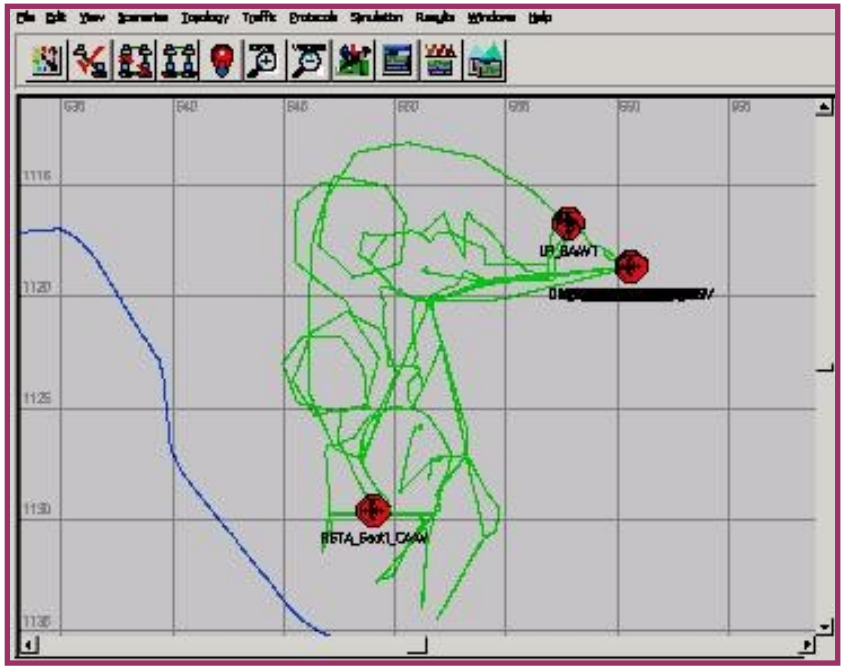

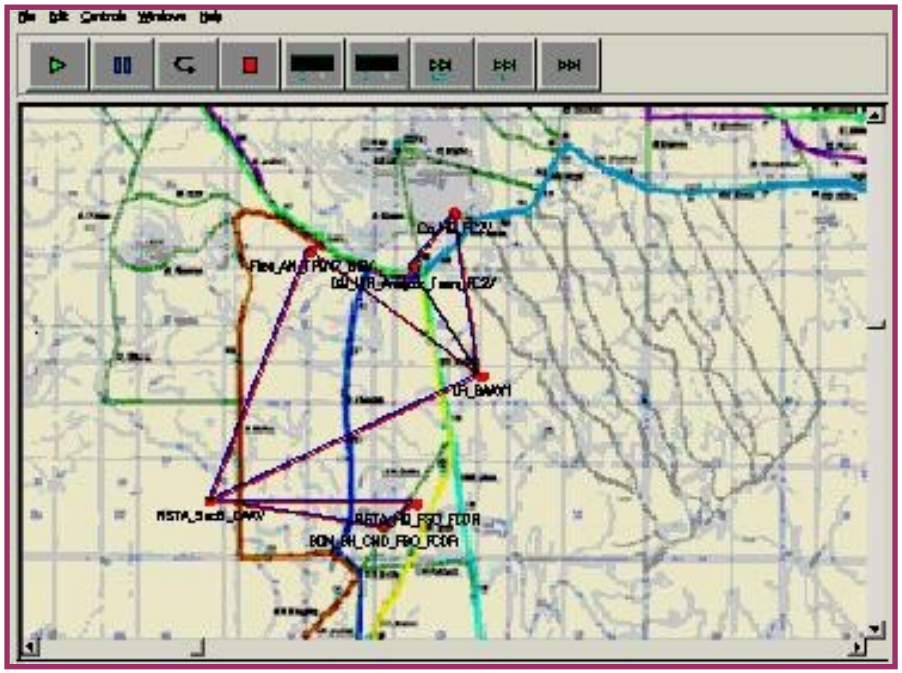

- Trajectories define node movement
- Animation to visualize connectivity

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Simulation Calibration

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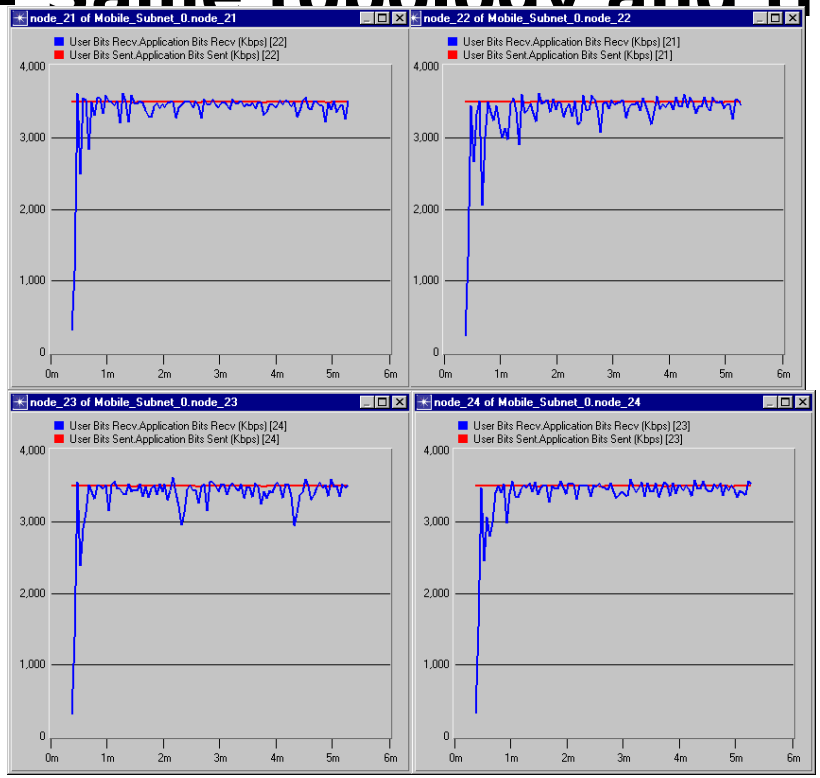
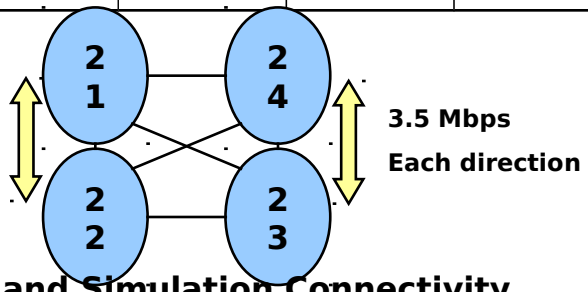
- Simulation results compared to lab test results
- Same topology and traffic profiles



Src	Dest	Tx Rate (Mbps)	MCR SIM	MCR LAB
21	22	3.5	96.0	93.7
22	21	3.5	96.0	96.4
23	24	3.5	96.5	95.0
24	23	3.5	96.6	94.5



Lab and Simulation Connectivity

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Field data fed back into simulations

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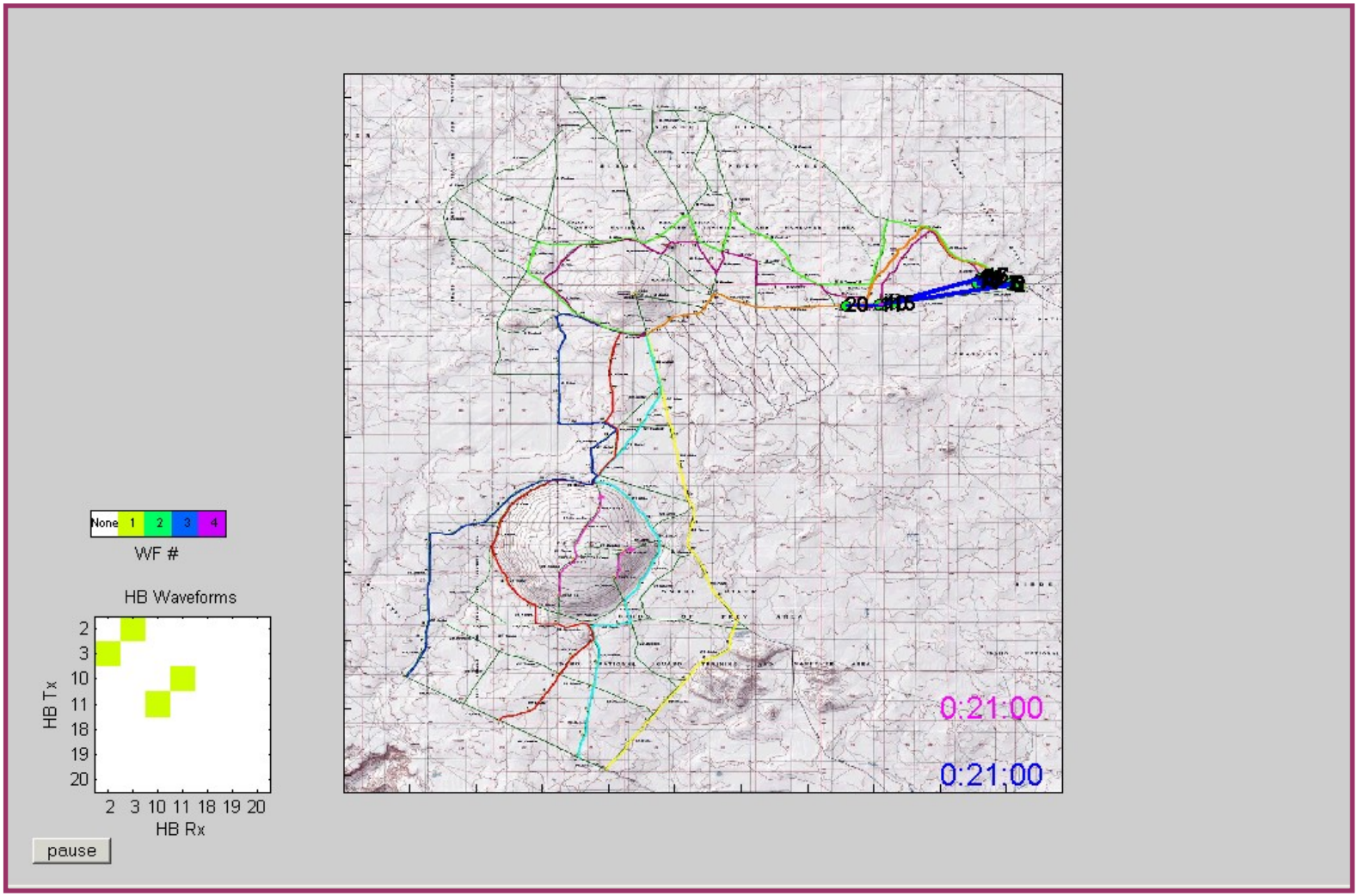

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Data Analysis Effects Simulation Trades

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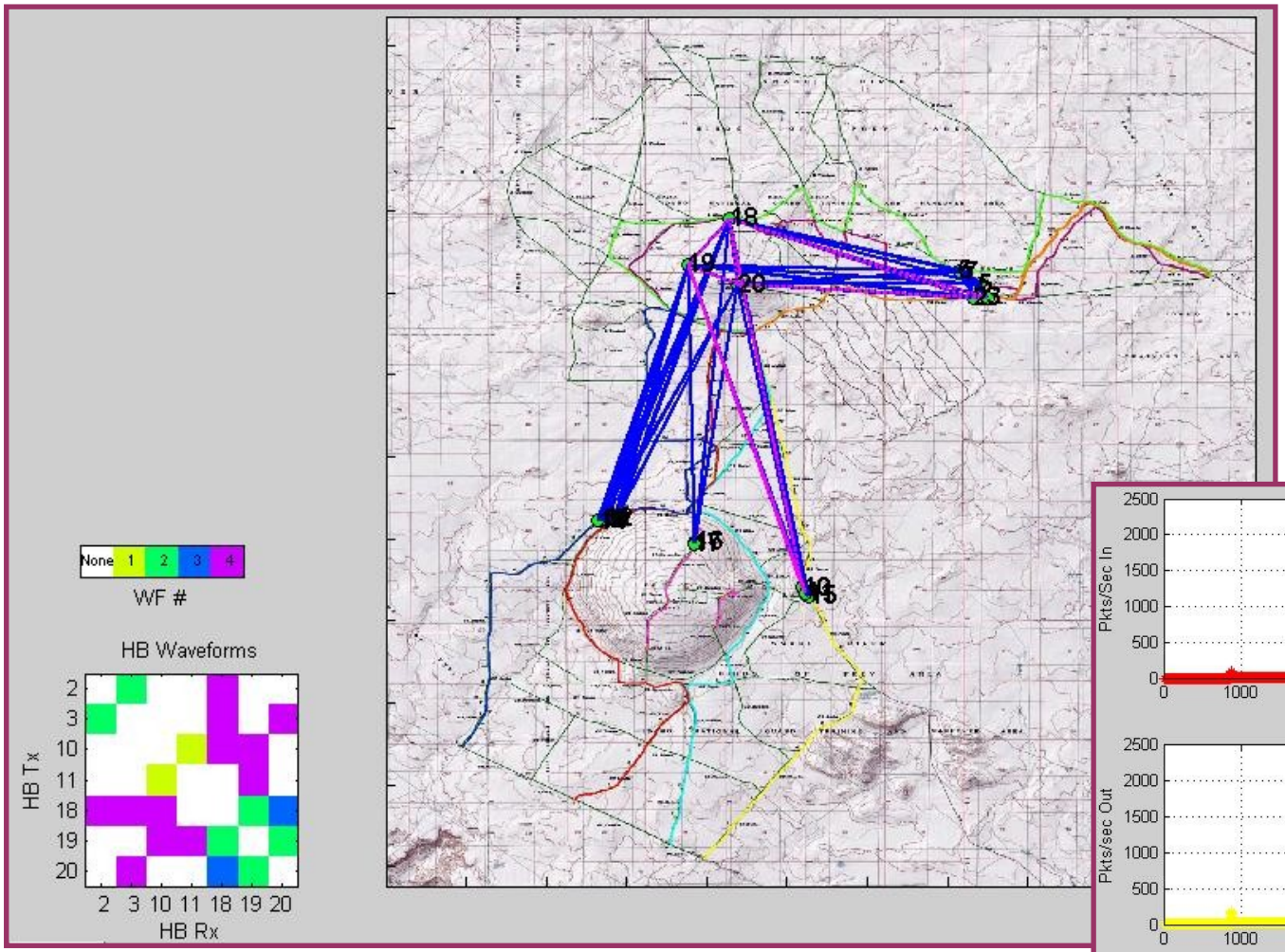
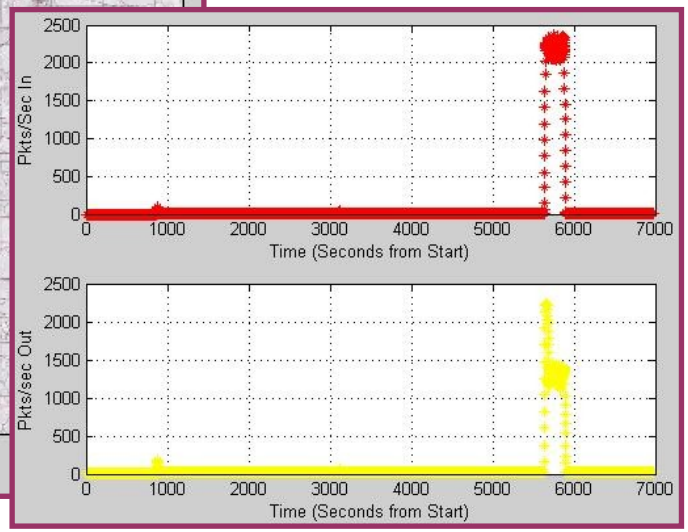


- Field data collected and analyzed
- Results used to design simulation trade studies



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Simulation Flexibility

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- **Physical Layer Independence**
  - **Focus on Scheduling**
- **MAC Scheme Comparisons**
  - **Overhead**
  - **Synchronization**
  - **Parameter Tuning**
  - **TDMA**
  - **CSMA/CA**
- **Routing Protocol Comparisons**
  - **Overhead**
  - **Parameter Tuning**
  - **Uni-cast**
  - **Multi-cast**
- **Protocol Interaction Sensitivity Analysis**
- **Early Expected Field Results Predictions**

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Conclusions

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- Using a combination of simulation and analysis tools is critical to network protocol development
- Iterative development and refinement of the protocols and models improves the fidelity and results produced in both the simulated and field environments.
- Simulation based protocol development reduces risk throughout the life cycle of a program.

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Questions

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